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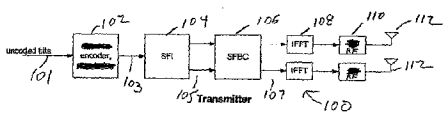
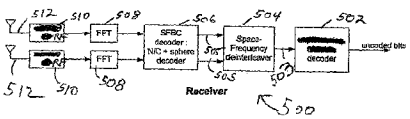
(54) Title: MULTICARRIER TRANSMITTER, MULTICARRIER RECEIVER, AND METHODS FOR COMMUNICATING MULTIPLE SPATIAL SIGNAL STREAMS





(57) Abstract: A multicarrier transmitter includes a space-frequency interleaver and a space-frequency coder to encode multicarrier signals for transmission over a plurality of spatial channels.

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INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L1/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	A PAULRAJ ET AL: "Introduction to Space-Time Wireless Communications" May 2003 (2003-05), CAMBRIDGE UNIVERSITY PRESS , CAMBRIDGE, UK , XP002318441 page 9 page 28 - page 29 page 182 - page 184 page 186, Chapter 9.4.3 - page 187, line 1 -/--	1,6-13, 15,19, 26,29

[X] Further documents are listed in the continuation of box C.

[ ] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2005	10/03/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Baltersee, J

INTERNATIONAL SEARCH REPORT

Int al Application No
PCT/US2004/029768

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RENDE D ET AL: "Bit interleaved space-frequency coded modulation for OFDM systems" ICC 2003. 2003 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS. ANCHORAGE, AK, MAY 11 - 15, 2003, IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS, NEW YORK, NY : IEEE, US, vol. VOL. 1 OF 5, 11 May 2003 (2003-05-11), pages 2827-2831, XP010642961 ISBN: 0-7803-7802-4 page 2828, left-hand column, lines 6-17 figure 1	1,5-9, 15,18, 19,26,29
A	HEMANTH SAMPATH: "Linear Precoding and Decoding for Multiple Input Multiple Output (MIMO) Wireless Channels" DISSERTATION SUBMITTED TO THE DEPARTMENT OF ELECTRICAL ENGINEERING AND THE COMMITTEE ON GRADUATE STUDIES OF STANFORD UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY, XX, XX, April 2001 (2001-04), page 157COMPLETE, XP002245817 Chapter 5.1.2	1,5-13, 15,18, 19,26,29

INTERNATIONAL SEARCH REPORT

tional application No.
PCT/US2004/029768

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 2-4, 14, 16, 17, 20-25, 27, 28, 30, 31
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 2-4, 14, 16, 17, 20-25, 27, 28, 30, 31

1.1 The subject-matter of dependent claims 2-4, 16, 17, 27, 28, 30, and 31 is related to specific embodiments of the space-frequency interleaver and the space-frequency coder. According to these claims, the space-frequency coder selects coded symbols for precoding together from diagonal positions of the interleaver matrix.

However, by merely specifying that coded symbols are selected from diagonal positions of an interleaver matrix and subsequently precoded, it remains entirely unclear to which combination of subcarrier and spatial channel each resulting precoded symbol is assigned. In fact, the mapping to subcarriers and spatial channels as determined by the position of a coded symbol in the interleaving matrix, is completely obscured by the diagonal selection process.

The skilled person who wants to put the invention as claimed by said claims into practice would thus consult the description. The description, however, is completely silent on the subject. It is thus concluded, that the invention is not disclosed in the description in a mannter sufficiently clear and complete to be carried out by a skilled person (Art. 5 PCT).

Furthermore, the features of assigning sequential bits diagonally, or selecting from diagonal positions, are unclear as such, since a matrix may have many different diagonals. For example, a 3x3 matrix has one diagonal of length 3, and two each of lengths 2 and 1. It is thus unclear which diagonals to choose, whether all diagonals are involved, and consequently whether precoded symbols may comprise a linear combination of a different number coded symbols.

The person skilled in the art would thus consult the description to put the invention into practice. It appears that the only additional information is disclosed on page 5, lines 28-33, page 6, lines 1-8, page 8 and in Figures 2 and 4. There, an example is given for the case of 2 transmit antennas and 6 subcarriers. However, the coded symbols are neither assigned nor selected strictly along diagonals of the interleaver matrix. Futhermore, only these very limited examples are given, and no general rule is stated which would allow the skilled person to extend the teachings to matrices of other dimensions. These claims are therefore not adequately supported by the description as required by Art. 6 PCT.

1.2 According to claims 14, 20, and 23 a decoder with a null canceler iteratively cancels interference from received multicarrier signals on a per subcarrier basis. According to common general knowledge many different types of interference, such as thermal noise, intercarrier interference, intersymbol interference, multiple user interference, etc. may arise in a multicarrier system. The skilled person would therefore consult the description in order to learn what type of interference is actually cancelled by corresponding the embodiments.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

According to page 10, lines 32 up to page 11, line 1, interference caused by other subcarriers is cancelled. It thus appears that the invention actually addresses the problem of intercarrier interference in multiantenna multicarrier systems. The description, however does not contain any embodiments which would allow the skilled person to put an intercarrier interference canceller for multiantenna multicarrier systems into practice.

With respect to the null cancellation process, the description mentions cancellation of interference by way of maximum likelihood detection within a spherical limit on M layers, where M is the number of transmit antennas. Such features are more reminiscent of cancelling interference which is caused by spatial multiplexing. However, interference is not mentioned in the whole of the application to that respect.

Furthermore, according to claims 14 and 20, the decoder decodes groups of symbols to generate two or more associated bits, and deinterleaves these bits in a diagonal manner. In order to carry out the deinterleaving, the decoder has to reconstruct a matrix as shown by way of example in Figure 4. However, since the description does not disclose how the encoder maps the precoded symbols to the subcarriers and spatial channels, as set forth under Point 1.1, the person skilled in the art does not know how to devise the reverse process.

It is thus concluded, that the invention, as claimed by 14, 20, and 23 and the claims 21, 22, 24, and 25 dependent thereon, is not disclosed in the description in a mannter sufficiently clear and complete to be carried out by a skilled person (Art. 5 PCT).

Furthermore, the objection with respect to diagonal position within the interleaver matrix as detailed under Point 1.1 above are also valid for claims 14, 20-25, and thus these claims are not adequately supported by the description as required by Art. 6 PCT.

1.3 Due to the above objections, it is concluded in accordance with Art. 17(2)(a)(ii) PCT that the description and the claims fail to comply with the prescribed requirements to such an extent that a meaningful search could not be carried out for claims 2-4, 14, 16, 17, 20-25, 27, 28, 30, 31.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.